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New record of *Sturnira bakeri* Velazco & Patterson, 2014 (Chiroptera: Phyllostomidae) from northwestern Peru

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Abstract: *Sturnira bakeri* was recently described from southwestern Ecuador near the Peruvian border and was suggested to occur also in Peru. To confirm this hypothesis we present a morphological and morphometric revision of specimens of *Sturnira* collected from northwestern Peru. As result, we report the presence of *S. bakeri* from Peru and extend its distribution range southwestward by at least 32.3 km from previous occurrences, and we suggest that *S. luisi* is apparently absent from Peru. We also found evidence of sexual size dimorphism in *S. bakeri*.

Key words: *Sturnira luisi*; sexual dimorphism; distribution range; southwestern Ecuador

Currently, 22 species are recognized for the genus *Sturnira* Gray, 1842 (Phyllostomidae), but this number could increase due to ongoing taxonomic revision (Velazco and Patterson 2014; Solari and Matinez 2015). Recently, Velazco and Patterson (2013) investigated the phylogenetic and biogeographic relationships among *Sturnira* species using molecular markers. They found support to the *S. lilium* species complex conformed by seven species, two of them new. One of these was recently described as *Sturnira bakeri* Velazco & Patterson, 2014 and is characterized as a medium-sized bat with tetracolored dorsal hair, tricolored ventral hair, the IV metacarpal shorter than the III metacarpal, a globular braincase with a slender rostrum, well-developed sagittal crest and the clinoid process, and by a straight zygomatic arch (Velazco and Patterson 2014). *Sturnira bakeri* was reported from the dry forest of the southwestern Ecuador near to Peru, which is reason why Velazco and Patterson (2014) suggested that *S. bakeri* could be present in Peru. Therefore, to corroborate the presence of *S. bakeri* in Peru, we examined *Sturnira* specimens from northern Peru. Because *S. bakeri* is confused with *S. luisi* Davis, 1980, we also determined the presence and distribution of *S. luisi* in Peru. Additionally, we investigated whether sexual dimorphism is present in *S. bakeri* because dimorphism is reported in other species of *Sturnira* (Tamsitt and Valdivieso 1986; Gannon 1989; Pacheco and Patterson 1992; Gardner 2008; Camargo et al. 2012) and because dimorphism of diagnostic features could confuse species differentiation.

A total of 53 specimens of *Sturnira* from northwestern Peru were revised using the features described for *S. bakeri* by Velazco and Patterson (2014) to confirm if they correspond to *S. luisi* or *S. bakeri*. Moreover, external and craniodental measurements were taken following Davis (1980), Pacheco and Patterson (1992), and Velazco and Patterson (2014) to analyze sexual size dimorphism. Five external measurements were obtained from specimens' labels: head body length (HBL), hind foot length (HF), ear length (EL), tragus length (TRL), and forearm length (FA). In addition, 15 craniodental variables were measured from 31 adult specimens (20 ♀ and 11 ♂): greatest skull length (GSL), condylobasal length (CBL), palatal length (PALTL), maxillary toothrow length (MXTRL), zygomatic width (ZYGW), mastoid breath (MB), postorbital width (POW), braincase width (BRW), width at M2 (M2–M2), width at canines (CC), braincase height (BRH), dentary length (DENL), mandibular toothrow length (MANDL), and dentary thickness (DENT) (Table 1). These specimens were collected at six localities in northern Peru, and are housed in the collection of mammals of Museo de Historia Natural de la Universidad Nacional Mayor de San Marcos (MUSM).

We use the Mann-Withney U test to evaluate significant differences between sexes based on body and craniodental measurements. Because sample size was

Table 1. External and skull measurements (in mm) of *Sturnira bakeri* from Tumbes, Peru, and measurements of the holotype of *S. bakeri* from El Oro, Ecuador (Velazco and Patterson 2014). Average and standard deviation is followed by the range in parenthesis and sample size.

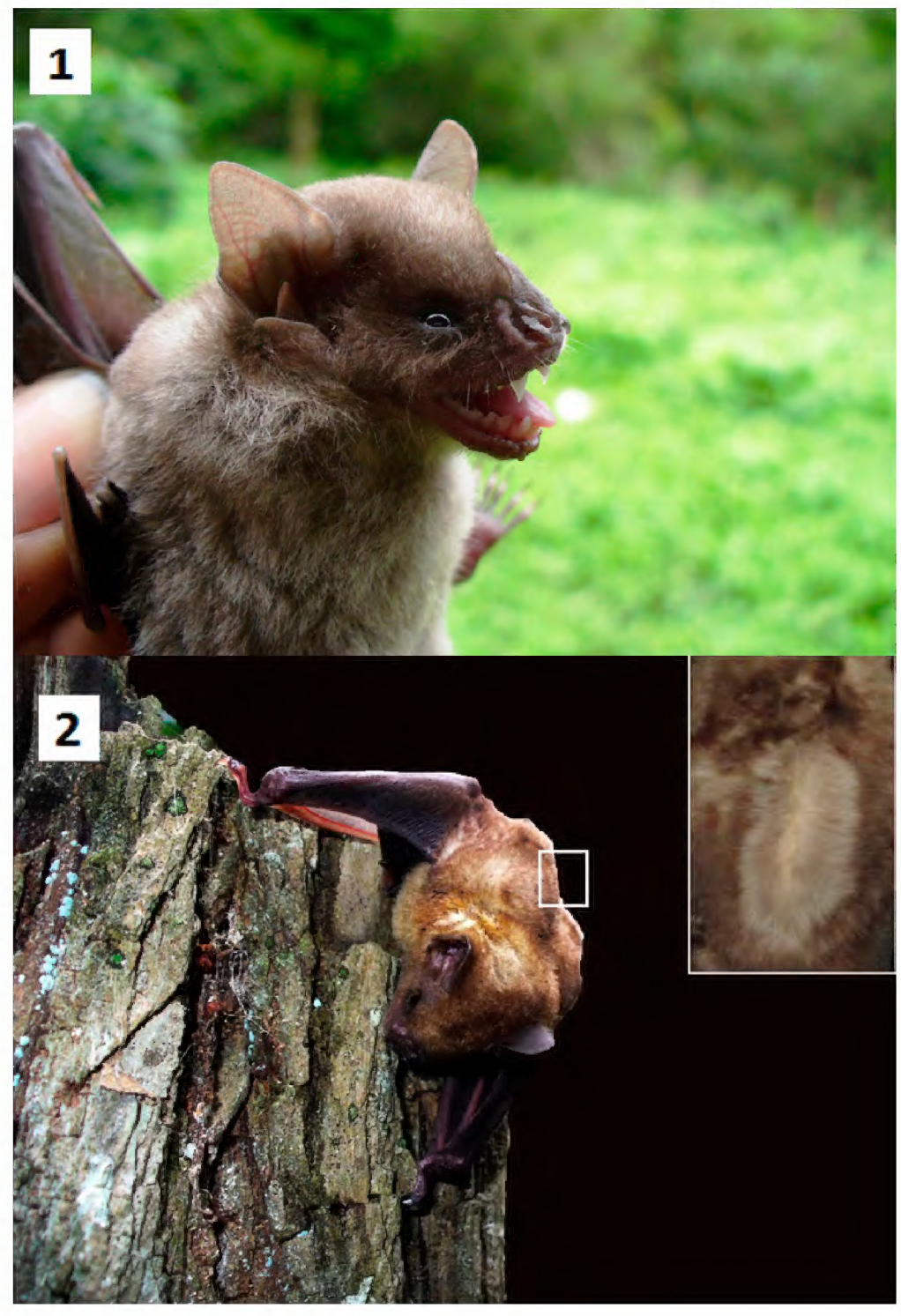
	Ecuador	Peru	Peru
Measure	**Holotype (f)**	**Female (f)**	**Male (m)**
HBL*	65	64.5 ± 2.40 (59–69) 20	70.27 ± 3.35 (66–77) 11
HFL*	14	12.08 ± 2.00 (7.5–15) 20	14.95 ± 2.71 (12–20) 11
EL	14	17.18 ± 1.58 (12–19) 20	17.64 ± 1.36 (16–20) 11
TRL	—	7.05 ± 1.09 (5–9.5) 20	5.95 ± 1.21 (3.5–8) 11
FA*	45	43.11 ± 1.05 (41–45.5) 20	44.54 ± 1.20 (43.25–47.65) 11
GSL*	22.7	22.47 ± 0.39 (21.96–23.3) 20	23.17 ± 0.47 (22.46–23.86) 11
CBL*	21.1	20.64 ± 0.34 (19.96–21.21) 20	21.15 ± 0.46 (20.67–21.97) 11
CCL*	—	19.91 ± 0.31 (19.41–20.69) 20	20.45 ± 0.41 (19.87–21.22) 11
PALTL*	—	9.36 ± 0.37 (8.78–10.16) 20	9.73 ± 0.37 (9.03–10.51) 11
MXTRL*	6.9	6.63 ± 0.13 (6.44–6.82) 20	6.86 ± 0.15 (6.63–7.11) 11
ZYGW*	13.5	13.57 ± 0.32 (12.87–14.33) 20	13.97 ± 0.30 (13.42–14.34) 11
BRW*	10.4	10.41 ± 0.19 (9.88–10.66) 20	10.58 ± 0.27 (10.08–10.92) 11
MB*	11.9	11.84 ± 0.22 (11.52–12.19) 20	12.19 ± 0.37 (11.37) 11
POW	5.9	5.89 ± 0.16 (5.58–6.21) 20	5.99 ± 0.23 (5.66–6.42) 11
M2M2*	8.3	8.11 ± 0.17 (7.87–8.49) 20	8.45 ± 0.15 (8.22–8.65) 11
C1C1*	—	5.91 ± 0.22 (5.43–6.34) 20	6.25 ± 0.22 (6.02–6.7) 11
BRH	—	8.76 ± 0.29 (8.37–9.48) 20	8.92 ± 0.29 (8.52–9.56) 11
DENL*	15	14.83 ± 0.30 (14.32–15.38) 20	15.41 ± 0.39 (14.82–15.86) 11
MANDL*	7.7	7.3 ± 0.18 (6.95–7.67) 20	7.69 ± 0.19 (7.46–8.05) 11
DENT*	—	2.25 ± 0.12 (2.02–2.53) 20	2.34 ± 0.18 (1.89–2.6) 11

* Measures that show significance ($p < 0.05$) to sexual size dimorphism.

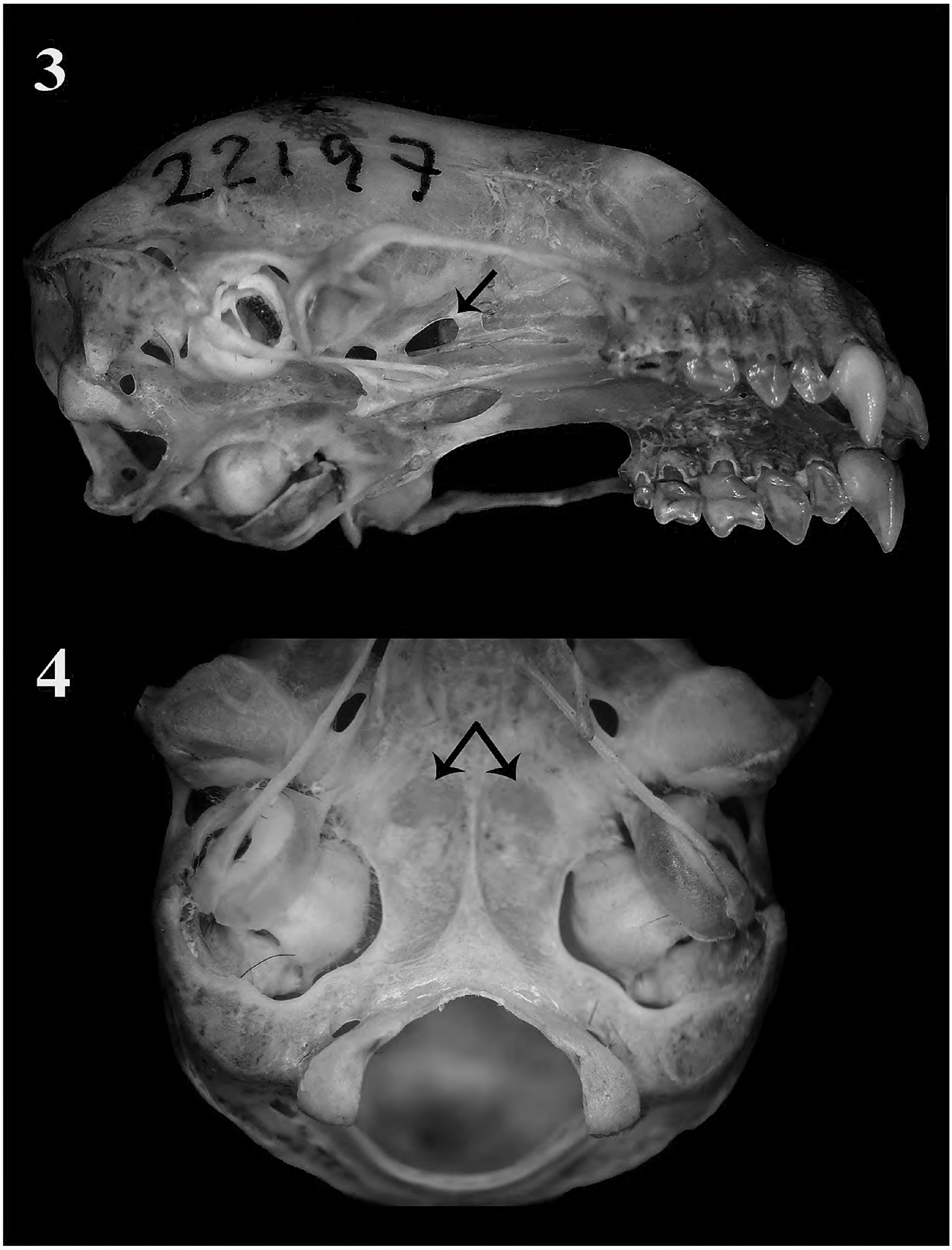
limited, all specimens were considered as representative of a single population based on proximity and lack of any potential barrier between them. Statistical analyses were performed using the statistic application PAST3 (Hammer et al. 2001).

All of our specimens were identified as *S. bakeri* and no specimen was identifiable as *S. luisi* based on features described by Velazco and Patterson (2014). The characters mentioned in the diagnosis and description of *S. bakeri*, were: tetracolored hairs on dorsum (Figures 1 and 2); tricolored hairs on ventral fur; oval sphenorbital fissure and the shallow basisphenoid pits with a low midline septum (Figures 3 and 4), which are morphological traits different to the bicolored hair in dorsal and ventral fur; subcircular sphenorbital fissure; and shallow basisphenoid pits with a high midline septum present in *S. luisi*. We note that the hair pattern is easier observed with specimens preserved in fluid than in those preserved as dry skins, where a tetracolor hairs can be confused with a tricolored hairs because the white basal band is difficult to distinguish.

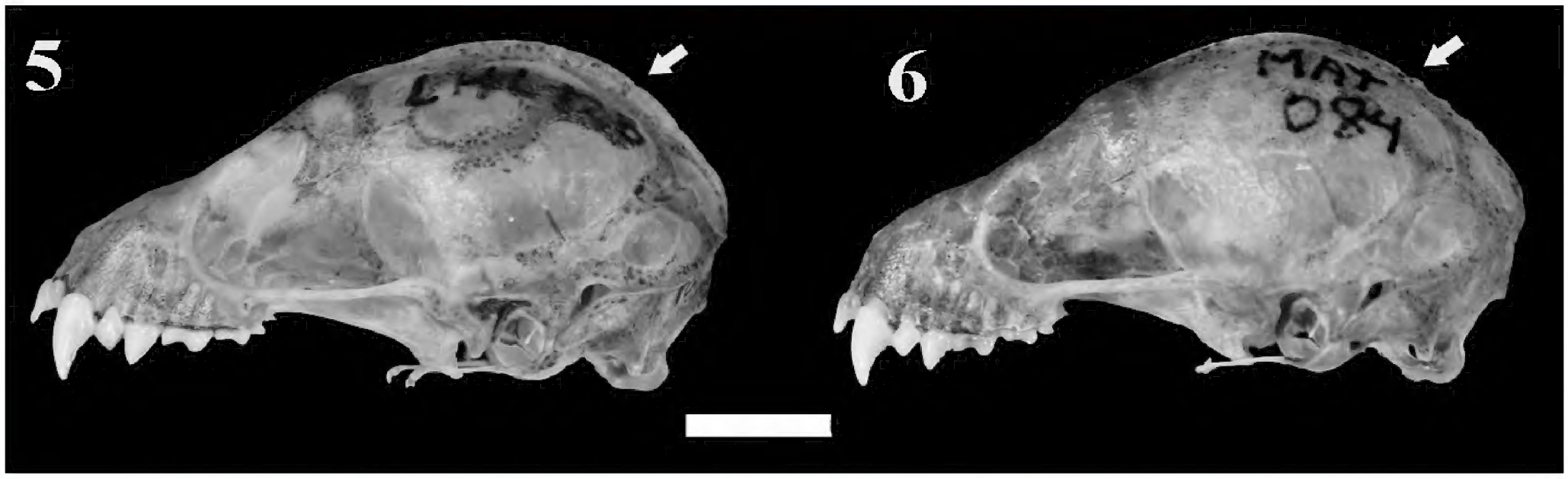
We found also that other characters mentioned in the diagnosis and description of *Sturnira bakeri* were variable (Figures 7–12; Table 2). In *S. bakeri,* the color of the dorsal pelage is supposed to be pale brown, but in 85% of our samples it was dark brown with some white parts due to the wide portion of the second band of the hairs. In *S. bakeri*, the IV metacarpal was said to be shorter than the III metacarpal, but in 90% of our samples the IV and III metacarpals were subequal in size. In addition, a well-developed sagittal crest was described for *S. bakeri,* but only 55% of our samples



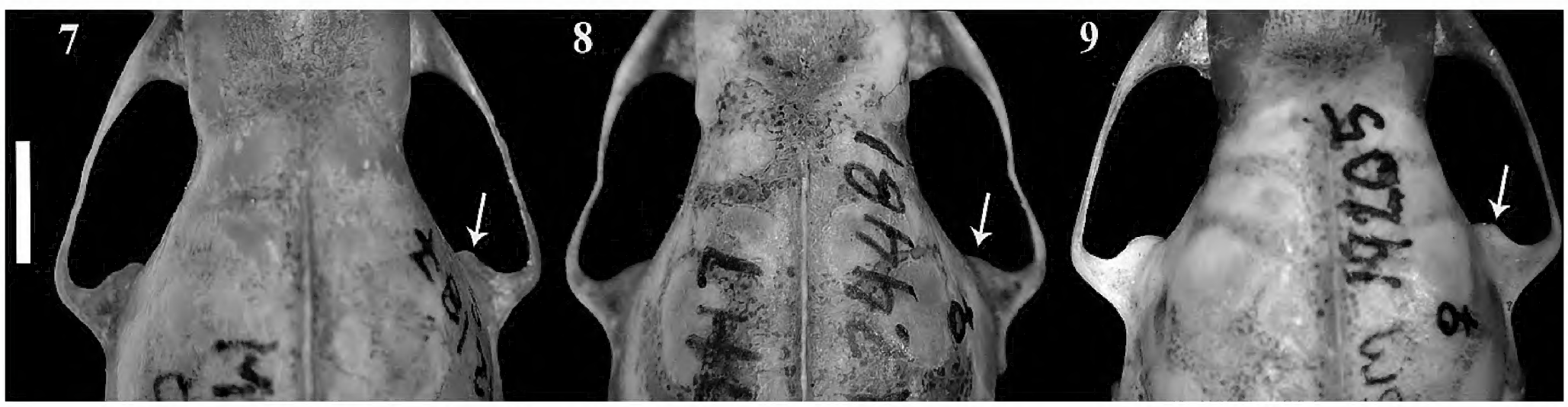
Figures 1 and 2. Live photograph of Baker's Yellow-shouldered Bat, *Sturnira bakeri* collected in Tumbes, Peru. **1:** Lateral view of *Sturnira bakeri.* **2:** Specimen of *Sturnira bakeri* on a tree trunk, notice the tetracolored hair. Photos by Richard Cadenillas.



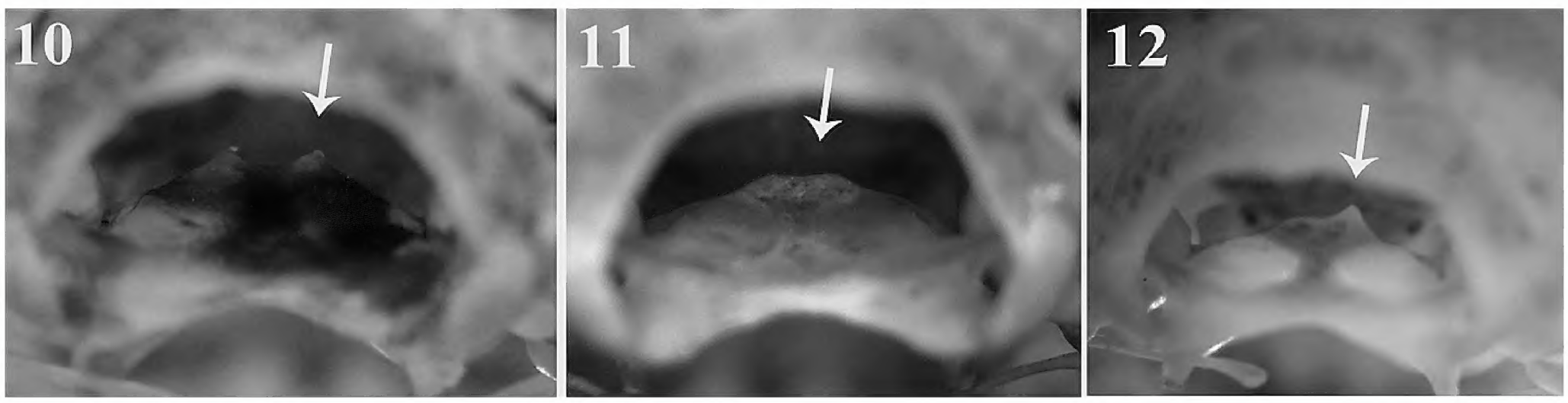
Figures 3 and 4. Craniodental features in specimens of *S. bakeri* from Peru (MUSM 22197). **3:** Oval shape of sphenorbital fissure. **4:** The basisphenoid pits are shallow and divided by a low midline septum.



Figures 5 and 6. Two states of sagittal crest (SC) observed in *Sturnira bakeri* from Peru. **5:** Sample with a well-developed SC (MUSM 24481). **6:** Specimen with a poorly-developed SC (MUSM 22187). Scale bars = 5 mm.



Figures 7–9. Different states of the anterior process of the glenoid fossa (see the arrows). **7:** Developed only on the right side (MUSM 22187). **8:** The process are absent (MUSM 24481). **9:** Well-developed process (MUSM 19205). Scale bars = 2mm.



Figures 10–12. Different states of the clinoid process (CP) (see the arrows). **11:** CP present (MUSM 24481). **12:** CP absent (MUSM 22187). **13:** CP partially developed (MUSM 19198).

comply with that, and most of them were male (79%), which suggests a possibly sexual dimorphic trait. The absence of the anterior process of the glenoid fossa was described for *S. bakeri* but only 6% of our samples were like the holotype. In addition, well-developed clinoid process were described for *S. bakeri* but it was the most variable feature in our samples, because only 33% were like the holotype, 24% lacked the clinoid process and 43% had a poorly developed clinoid process.

This work confirms the first records of *S. bakeri* from Peru, and extends this species' distribution by 32.3 km southwest from El Oro, Reserva Militar Arenillas (Ecuador) to San Jacinto, El Prado in Tumbes (Peru). In total, we add six new localities for this species (Figure 13). Three of them belong to the Dry Forest region composed primarily of *Ceiba trichistranda* and *Triplaris cumingiana* (Leal-Pinedo 2005; Aguirre et al. 2006; Pacheco et al. 2007), as at the type locality. The other three localities correspond to the Pacific Tropical Rainforest biome, where the canopy may reach up to 30 m high and the vegetation is dominated by *Aiphanes* sp., *Triplaris cumingiana*, and *Cecropia* spp. (Pacheco et al. 2007).

Additionally, we found evidence of sexual size dimorphism (Mann-Withney U test $p < 0.05$) in three external (HBL, HFL, FA) and 13 craniodental measurements (GSL, CBL, CCL, PALT, MXTRL, ZYGW, BRW, MB, M2M2, CC, DENL, MANDL, DENT), indicating that females are smaller than males (Table 1). This may

Table 2. Frequency of character states per sex and in total in variable characters of *S. bakeri*. Diagnostic characters described in literature for *S. bakeri* are appointed with letter "X".

	Well-developed sagittal crest	Poorly developed sagittal crest	The anterior process of glenoid fossa absent	Poorly developed anterior process of glenoid fossa	Well-developed anterior process of glenoid fossa	Clinoid processes absent	Poorly developed clinoid processes	Well developed clinoid processes
S. bakeri (Holotype)*	X	—	X	—	—	—	—	X
female (*n*=19)	37%	63%	5%	74%	21%	32%	26%	42%
male (*n*=14)	79%	21%	0%	92%	15%	14%	64%	21%
Total (*n*=33)	55%	45%	6%	78%	16%	24%	42%	33%

*From Velazco and Patterson (2014).

explain why the measurements of holotype (a female specimen) agree more with the mean or range measurements of our female than male specimens.

We confirm the presence of *Sturnira bakeri* in northwestern Peru, in the Dry Forest ecoregion, as at the type locality, and in the Pacific Tropical Rainforest, following the classification of Brack E. (1986). This shows that *S. bakeri* is not specific of the Dry Forest areas as documented for other species of bats as *Lonchophylla hesperia* G. M. Allen, 1908; *Amorphochilus schnablii* W. Peters, 1877; *Tomopeas ravus* Miller, 1900; *Artibeus fraterculus* Anthony, 1924; *Eumops wilsoni* Baker et al, 2009 (Albuja 1991; Pacheco et al. 2007; Gardner 2008; Baker et al. 2009; Tirira et al. 2011). However, *S. bakeri* is restricted to the northwestern Peru and southwestern Ecuador and represents another endemic species for the Tumbesian region, as *Platyrrhinus matapalensis* Velazco, 2005 and *Proechimys decumanus* Thomas, 1899 (Velazco 2005; Patton and Leite 2015). Our findings support the importance of conserving this region for its high number of endemic species of animals and plants (Best and Kessler 1995; Flanagan et al. 2005).

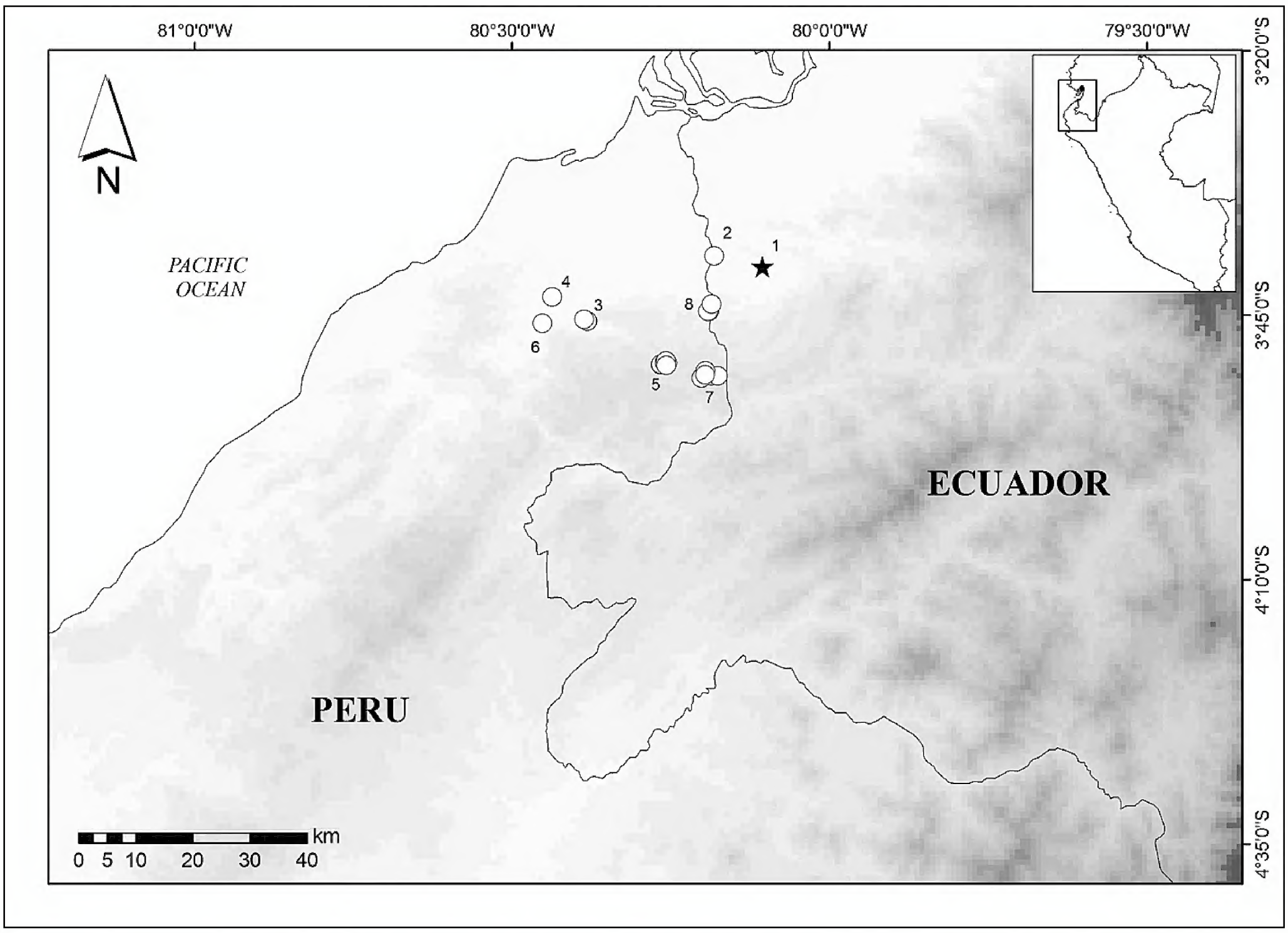


Figure 13. Distribution range of *Sturnira bakeri* in northwestern Peru and southwestern Ecuador. Numbers indicate the new and previously localities reported, which are specified in the Appendix. Type locality are represent by a star (★).

None of our specimens were found to be *S. luisi*, and we suggest that this species is probably absent from Peru. However, Gardner (2008) mentioned that *S. luisi* is present in Peru, with the southernmost record from Quebrada, La Pachinga, Las Juntas, Piura (based on specimen LMUSZ 27256), but this material needs to be re-examined because it might be *S. bakeri*. If that is true, the distribution of *S. bakeri* would extend much further south and support our hypothesis that *S. luisi* does not occur in Peru. We suggest that *S. luisi* is distributed from Central America (Costa Rica and Panama) to northwestern Ecuador (Esmeraldas) in the more humid biome known as the Choco region, but this needs corroboration by a more extensive revision using both morphological and molecular analyses.

Davis (1980) mentioned a straight zygomatic arch that converge anteriorly and the parallel maxillary toothrow as diagnostic features of *Sturnira luisi* to differentiate it from *S. lilium*, but because these traits are also present in *S. bakeri*, other diagnostic features are necessary to correctly determine *S. luisi*. Velazco and Patterson (2014) provided additional characteristics to differentiate *S. bakeri* from *S. luisi* but several of them were found to be variable in our samples, especially the presence of the clinoid process which may or may not be present in Peruvian *S. bakeri*. Velazco and Patterson (2014) failed to find morphological variation because they used only one specimen to describe the craniodental traits of *S. bakeri*, and used only two specimens of *S. luisi* for morphological comparisons. We recommend that a larger series be used to describe new species to better appreciate the variability of the characters, especially when a new taxon belongs to a complex group.

We found sexual size dimorphism in *S. bakeri*, with the main variables to separate sexes being CBL, LHB and FA. Males are larger than females. Sexual size dimorphism has been reported in other species of *Sturnira*, such as *S. lilium* É. Geoffroy St.-Hilaire, 1810; *S. magna* de la Torre, 1966; *S. ludovici* H. E. Anthony, 1924 and *S. oporaphilum* Tshudi, 1844 (Willing 1983; Pacheco and Patterson 1992; Tamssit and Valdivieso 1986; Gardner 2008) where males were larger than females. *Sturnira bakeri* therefore confirms that sexual dimorphism is quite frequent in the genus.

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APPENDIX

Localities and specimens of *Sturnira* included in this study. Only specimens from Peru were examined in this study. Samples marked by an asterisk represent adult specimens measured and analyzed for sexual dimorphisms, while superscript ([1]) represent specimens revised by Velasco and Patterson (2014).

Sturnira bakeri — Ecuador (*n*=3): **(1)** *El Oro*: Reserva Militar Arenillas, Palmales, 03°40′27.40″ S, 080°06′20.00″ W, 49 m (QCAZ 14635[1] [holotype]); **(2)** Fuerte Militar Arenillas (7.1 km W and 12.5 km S of the Military Base), Quebrada Seca, 03°39′24.1″ S, 080°10′56.20″ W, 43 m (QCAZ 9737[1], 9739[1]). Peru (*n*=55): *Tumbes*: **(3)** Tumbes, Pampas del Hospital, Angostura-Platanal, 03°45′33.01″ S, 080°22′55.92″ W, 68 m (MUSM 22187*–22195*); Tumbes, Pampas del Hospital, Quebrada Angostura, 03°45′33.01″ S, 080°22′55.99″ W, 68 m (MUSM 19369, 19370*, 19371–19373); Tumbes, Pampas del Hospital, Quebrada Angostura, 03°09′23.00″ S, 080°23′15.00″ W, 74 m (MUSM 22196*); **(4)** Tumbes, Pampas del Hospital, Quebrada Cabuyal, 03°43′16.40″ S, 080°26′15.68″ W, 27 m (MUSM 20668*–20670*); **(5)** Tumbes, Pampas del Hospital, Quebrada Faical, 03°49′28.99″ S, 080°15′36.00″ W, 321 m (MUSM 19374–19382); Tumbes, Pampas del Hospital, Quebrada Faical, 03°49′26.04″ S, 080°15′37.08″ W, 330 m (MUSM 19203); Tumbes, Pampas del Hospital, Quebrada Faical, 03°49′19.99″ S, 080°15′29.99″ W, 347 m (MUSM 19383, 24481*); Tumbes, Pampas del Hospital, Quebrada Faical, 03°49′36.84″ S, 080°15′57.96″ W, 357 m (MUSM 19198* – 19200*,19202*); Tumbes, Pampas del Hospital, Quebrada Faical, 03°49′34.68″ S, 080°15′21.60″ W, 357 m (MUSM 19204*); Tumbes, Pampas del Hospital, Quebrada Faical, 03°49′41.88″ S, 080°15′57.96″ W, 364 m (MUSM 19197*, 19201*); Tumbes, Pampas del Hospital, Quebrada Faical-Z.R.Tumbes, 03°49′36.98″ S, 080°15′58.00″ W, 600 m (MUSM 10731*); Tumbes, Pampas del Hospital, Quebrada Las Pavas, 03°49′43.00″ S, 080°15′28.01″ W, 334 m (MUSM 22197*, 24482*); **(6)** Tumbes, San Jacinto, El Prado, 03°45′45.79″ S, 080°27′11.09″ W, 89m (MUSM 20671*); **(7)** Zarumilla, Matapalo, Campo Verde, 03°50′44.02″ S, 080°11′11.18″ W, 570 m (MUSM 19365, 19366, 19367*, 19368); Zarumilla, Matapalo, Quebrada Naranjos, 03°50′15″ S, 080°11′44.99″ W, 550 m (MUSM 19384); Zarumilla, Matapalo, Quebrada Naranjos, 03°50′54.96″ S, 080°12′9.0″ W, 770 m (MUSM 19205*); Zarumilla, Matapalo, Naranjal, 03°50′37.0″ S, 080°11′48.98″ W, 780 m (MUSM 22198); **(8)** Zarumilla, Matapalo, Río Zarumilla-Carrizalillo, 03°44′37.68″ S, 080°11′02.46″ W, 173 m (MUSM 22199, 22200, 22201*, 22202); Zarumilla, Matapalo, Río Zarumilla-Carrizalillo, 03°44′38.00″ S, 080°11′32.17″ W, 201 m (MUSM 22203*); Zarumilla, Matapalo, Río Zarumilla-Cavaña INRENA, 03°43′56.71″ S, 080°11′10.57″ W, 125 m (MUSM 22204*).